

MODELING THE LOW STATE SPECTRUM OF THE X-RAY NOVA XTE J1118+480

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To appear in the Astrophysical Journal

ABSTRACT

Based on recent multiwavelength observations of the new X-ray nova XTE J1118+480, we can place strong constraints on the geometry of the accretion flow in which a low/hard state spectrum, characteristic of an accreting black hole binary, is produced. We argue that the absence of any soft blackbody-like component in the X-ray band implies the existence of an extended hot optically-thin region, with the optically-thick cool disk truncated at some radius $R_{\text{tr}} \gtrsim 55 R_{\text{Schw}}$. We show that such a model can indeed reproduce the main features of the observed spectrum: the relatively high optical to X-ray ratio, the sharp downturn in the far UV band and the hard X-ray spectrum. The absence of the disk blackbody component also underscores the requirement that the seed photons for thermal Comptonization be produced locally in the hot flow, e.g. via synchrotron radiation. We attribute the observed spectral break at ~ 2 keV to absorption in a warm, partially ionized gas.

Subject headings: accretion, accretion disks – stars: individual: XTE J1118+480 – X-ray: stars

1. INTRODUCTION

There is now solid evidence for the presence of black holes within a number of X-ray binaries. A low/hard state, characterized by a power-law spectrum with photon index of $1.4 - 1.8$ and extending to ~ 100 keV, is observed both in transient systems (X-ray novae, e.g. GRS 1124-68, GRO J0422+32) and persistent systems (e.g. Cyg X-1, LMC X-3). It is generally assumed that these spectra are produced by thermal Comptonization of seed photons in the vicinity of an accreting black hole. However, the geometry of the accretion flow and the source of soft photons currently remains a point of debate. Recently two competing pictures have emerged. In the accretion disk corona model, a cool thin disk is embedded in a hot corona (thought to be heated by magnetic flares), which produces the hard power-law emission via inverse Compton scattering of the disk photons (e.g. Galeev, Rosner & Vaiana 1979; Haardt & Maraschi 1991; Haardt, Maraschi & Ghisellini 1994; Poutanen & Svensson 1996, and references therein). In the other scenario, the thin disk is truncated at some large inner radius and the bulk of the emission forms in a hot quasi-spherical accretion flow through Comptonization of locally produced synchrotron and bremsstrahlung radiation (e.g. Shapiro, Lightman & Eardley 1976; Ichimaru 1977; Esin, McClintock & Narayan 1997; Dove et al. 1997b; Esin et al. 1998).

The simplest way to distinguish between these two models would be to observe directly the emission from the inner edge of the thin disk. However, at accretion rates for which the low state is generally observed, $\lesssim 10\%$ of Eddington (see e.g. Nowak 1995), the thin disk emission peaks at energies $\lesssim 0.5$ keV. This region of the spectrum is strongly

affected by interstellar absorption and, until recently, has been at the edge of the sensitivity range for existing X-ray detectors. In the past, the attempts to distinguish between these two scenarios have been based mostly on modeling the X-ray reflection features (e.g. Gierliński et al. 1997; Życki, Done & Smith 1997, 1998; Done & Życki 1999, though see also Dove et al. 1997b), the so called “reflection bump” centered at ~ 30 keV, and the iron fluorescence line at 6.4 keV (Guilbert & Rees 1988; George and Fabian 1991). However, the interpretation of these features is complicated by uncertainties in the models (Ross et al. 1999; Nayakshin et al. 2000).

Currently, this state of affairs is changing. Both Chandra and XMM are capable of observing soft X-rays down to ~ 0.2 keV with good energy resolution. In addition, a new black hole X-ray nova – XTE J1118+480 – was discovered on 2000 March 29 (Remillard et al. 2000) in a region with exceptionally low interstellar absorption (Garcia et al. 2000), which made possible the first extreme UV observation of an X-ray nova (Hynes et al. 2000, hereafter HEA). Based on near-simultaneous optical, UV, and X-ray observations, HEA concluded that the source appeared to be in a low state (typical of black hole systems) with a power-law spectrum extending down to ~ 100 eV; the photon index was 1.8 ± 0.1 . The authors suggested that these data are inconsistent with the thin disk extending to the last stable orbit.

In this paper we present detailed modeling of the combined near-simultaneous HST, EUVE, Chandra and RXTE observations of XTE J1118+480 (McClintock et al. 2001a, hereafter PI). The addition of the Chandra

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LETG spectrum bridges the gap between the EUV and X-ray data discussed by HEA, providing us with a complete description of this previously inaccessible part of the spectrum. This is especially important because of the claim based on a 2000 May 11-12 ASCA observation (Yamaoka, Ueda & Dotani 2000) that the spectrum of XTE J1118+480 showed a slight soft excess that is consistent with a blackbody component of temperature 0.2 keV. Clearly this is inconsistent with the Chandra data. Moreover, in view of the source stability in radio, optical and X-rays (PI), the spectrum is not likely to have changed between the two observations. We argue that the combined spectrum allows us, for the first time, to place direct limits on the low state accretion geometry in the vicinity of the central object.

In §3 we show that a model based on an advection-dominated accretion flow surrounded by a truncated thin disk (described in §2) gives an excellent fit to the combined optical, UV and X-ray data. We argue in §4 that the observed spectrum rules out the presence of the standard thin accretion disk within ~ 55 Schwarzschild radii (R_{Schw}) and thereby presents a fundamental problem for the accretion disk corona models.

2. MODEL OVERVIEW

The basic model we use is described in detail in Esin et al. (1997) and Esin et al. (1998) and is briefly summarized below. Here we have added fully relativistic flow dynamics (Gammie & Popham 1998), gravitational redshift (Narayan et al. 1998) and the kinematic red-blue-shift of the emission due to the relativistic motion of the gas near the black hole horizon. In this model, the material transferred from a mass-losing secondary initially forms an optically thick, cool disk (Shakura & Sunyaev 1973) outside some radius, $R_{\text{tr}} \gtrsim 30 - 100 R_{\text{Schw}}$. Inside this radius the gas accretes via an optically thin, hot advection-dominated accretion flow (ADAF; see Narayan, Mahadevan, & Quataert 1998 and references therein).

The emission from such an accretion flow consists of two components. The first of these is the standard multicolor blackbody spectrum from an optically thick and cool outer disk. The effective temperature as a function of radius is determined by the viscous dissipation within the disk and irradiation of the disk surface by the inner ADAF. To compute the irradiation heating rate we assume that the thickness of the disk, H , is equal to the pressure scale height. The temperature and normalization of the thin disk spectrum is then determined mainly by four parameters: the black hole mass M , the inner and outer radii of the disk, R_{tr} and R_{out} , and $\dot{M}_{\text{disk}} \sim \dot{M}$.

The second emission component is produced in an optically thin, hot ADAF, where the electrons have temperatures of order $10^9 - 10^{10}$ K. In the presence of strong magnetic fields, such a gas cools through inverse Compton scattering of thermal synchrotron radiation. The spectrum is roughly a power-law with a high energy thermal cutoff at $100 - 200$ keV and a low energy cutoff in the IR/optical band due to synchrotron self-absorption. The slope of the power-law spectrum is determined mainly by $\dot{M}/(\alpha^2 \dot{M}_{\text{Edd}})$, where α is the standard viscosity param-

eter, which we take to be $\alpha = 0.25$. At $\dot{M} \sim 0.06 \dot{M}_{\text{Edd}}$, the photon index is close to 1.4 and it increases with decreasing \dot{M} . The high energy cutoff is determined by the electron temperature in the inner part of the flow, which depends most sensitively on β , the ratio of the gas pressure to the total pressure (from gas and magnetic fields).

2.1. Constraints on Model Parameters

XTE J1118+480 entered quiescence in October 2000, and subsequent spectroscopy of the optical counterpart placed fairly strong constraints on M , the distance to the system, d , and its binary inclination, i . McClintock et al. (2001b) and Wagner et al. (2001) independently confirmed the orbital period to be 4.1 hours (as previously suggested by Cook et al. 2000; Patterson 2000; Uemura et al. 2000; Dubus et al. 2001) and determined the value of the mass function to be $f(M) \simeq 6.0 M_{\odot}$. McClintock et al. (2001b) constrained the spectral type of the companion to lie in the range K5V-M1V, implying that its mass is a fraction of solar, and estimated the distance to be $d = 1.8 \pm 0.6$ kpc. They also argued that the observed photometric modulation, if attributed to ellipsoidal shape of the companion, implies $i > 40^\circ$.

In our model, for fixed values of α and β , the value of the mass accretion rate in Eddington units is set by the observed spectral slope. The relative normalization of the optical and X-ray emission components depends only on M and i ¹. Because the mass function $f(M)$ provides another relation between these two parameters, the best fit to the data uniquely determines both M and i , once \dot{M} , α and β are fixed ($f(M)$ also has a weak dependence on the mass of the companion, which we set to $0.4 M_{\odot}$). In our calculations we treat d and R_{tr} as free parameters; the former controls the overall normalization of the spectrum, and the latter determines the position of the thermal emission peak.

Finally, the outer radius of the accretion disk, R_{out} , is estimated using Paczyński's (1971) formula: $R_{\text{out}} = 3 \times 10^4 R_{\text{Schw}} (10 M_{\odot}/M)^{2/3}$, where we have taken the binary mass ratio to be < 0.1 (Dubus et al. 2001; McClintock et al. 2001b; Wagner et al. 2001), and assumed that the accretion disk fills 80% of the primary's Roche lobe.

3. RESULTS

Using the model described in §2, we have computed the best fit spectrum for the canonical parameter values $\alpha = 0.25$ and $\beta = 0.5$. This spectrum is shown as a dashed line in Fig. 1 together with the data from PI. With $\dot{M} = 0.035 \dot{M}_{\text{Edd}}$ and $R_{\text{tr}} = 65 R_{\text{Schw}}$ we can easily reproduce both the photon index of 1.8 required by the data in the range $2 - 30$ keV and the steep slope in the EUV band. To reproduce the ratio of X-ray and optical fluxes with this model, we need a very massive black hole, $M = 17 M_{\odot}$, with a disk inclined at $i = 45^\circ$, at a distance $d = 2.9$ kpc.

The UV-band energy slope of the model spectrum is fairly close to the canonical thin disk value of $1/3$. In fact, it is slightly flatter, as required by observations (HEA), due mainly to a contribution from the self-absorbed synchrotron emission below 1.5×10^{15} Hz. However, the disk

¹ The thin disk emission, which dominates in the optical, varies with inclination as $\cos i$, while we assume here that the ADAF geometry is close to spherical and so X-ray emission has practically no i -dependence.

emission steepens considerably below $\sim 5 \times 10^{14}$ Hz, so that the red end of the HST spectrum and the IR data points clearly lie above our model spectrum. This discrepancy decreases somewhat if R_{out} is a factor of 3 greater than the value we derived in §2.1. However, the presence of strong non-thermal radio emission in this system² suggests that the extra contribution to the IR (and possibly optical) emission comes from an entirely different source, perhaps an accretion disk outflow or a jet (e.g. Fender et al. 2000), or a small population of non-thermal electrons in the ADAF (e.g. Özel et al. 2000).

More important discrepancies between this model and the data are (1) the fact that our theory predicts a turnover in the hard X-ray band with a characteristic e -folding energy ~ 180 keV, while the summed RXTE data clearly show a power-law spectrum continuing to much higher energies; and (2) a lack of a spectral break at ~ 2 keV in the model spectrum.

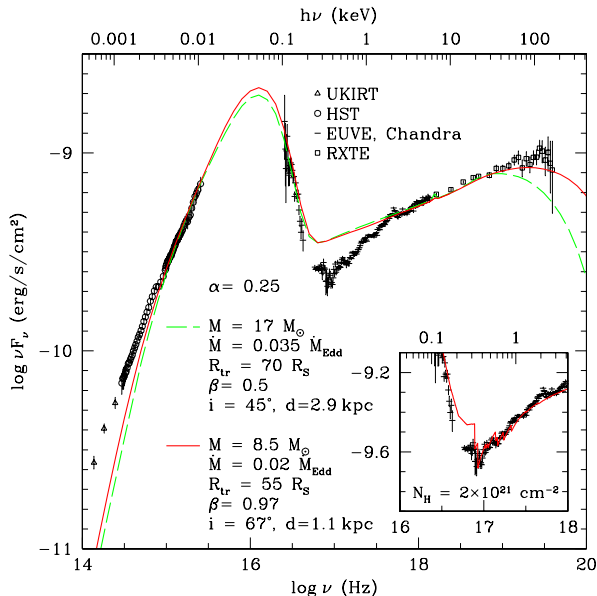


FIG. 1.— The model spectra for different parameter values are shown together with the data from PI, corrected for interstellar absorption with $N_H = 1.15 \times 10^{20} \text{ cm}^{-2}$ (see §4). The model in the inset incorporates the effects of a warm absorber (see text for details).

A spectrum calculated assuming a higher value of $\beta = 0.97$ (shown by the solid curve on Fig. 1) gives a much better fit to the data in the hard X-ray band. Higher β implies lower magnetic field strength in the accreting gas, and thus less synchrotron emission. The energy balance in the flow then requires a higher electron temperature to keep up the cooling rate, which moves the spectral cutoff to ~ 350 keV. In addition, increasing the value of β causes a decrease in the viscous dissipation rate in the ADAF³, and thus a decrease in its overall luminosity. As a result, this model can reproduce the observed X-ray to optical flux ratio with a relatively high inclination of $i = 67^\circ$ and smaller black hole mass, $M = 8.5 M_\odot$, and distance, $d = 1.1$ kpc. Because the accretion flow is hotter than with $\beta = 0.5$, the mass accretion rate required to reproduce the observed slope in the X-ray band decreases to $\dot{M} = 0.02 \dot{M}_{\text{Edd}}$. The

transition radius in this model is $R_{\text{tr}} = 55 R_{\text{Schw}}$.

The low B -field model leaves unexplained the broad dip in the data centered around 0.3 keV. In general, since X-ray emission in our model is produced in an optically thin region with a nearly constant electron temperature, the break in the power-law spectrum is difficult to reproduce; moreover, any scenario that relies on thermal Comptonization of low-energy seed photons to produce X-ray emission will encounter the same difficulty. Here we suggest that this feature in the observed spectrum is due to metal absorption in a partially ionized gas with $T \sim \text{few} \times 10^5$ K. At this temperature H and He are completely ionized, and since these elements are the main contributors to opacity below 200 eV, the presence of extra material does not affect the EUVE data. The abundant metals, C, N, O, Ne, etc., on the other hand, will be only partially ionized and their K -edge energies fall precisely in the range where absorption seems to be the strongest. Such a warm absorber model is commonly proposed to explain similar features in AGN spectra (see Komossa 2000, and references therein).

To illustrate this suggestion, we have approximated the effect of K -edge absorption by C, N, O, Ne and Mg, together with L -shell absorption by Fe, on our high- β model described above. Because the locations of the strongest absorption features near 300 eV are close to the K -edge energies of CIII and CIV, we have included only the contribution from these stages of ionization for all the metals. (We realize that this is a major approximation and that a realistic model would require solving the full ionization balance equations). The result is shown in the inset in Fig. 1 for $N_H \sim 2 \times 10^{21} \text{ cm}^{-2}$. (All elements, except O, are assumed to have solar abundances; because of the absence of a strong O edge, we have reduced its abundance by a factor of 3.) Because of its simplicity, this is not meant to be a real model; nevertheless, it demonstrates that photoelectric absorption (with its characteristic frequency dependence of optical depth, $\tau \propto \nu^{-8/3}$) can indeed reproduce the general shape of the soft X-ray spectrum. Note that the discrepancy between our toy model and the data at energies below the C K -edge is most likely due to the contribution of L -shell absorption, which we neglected here.

It is important to point out that the thin disk is *not* a significant source of seed photons for inverse Compton cooling of the gas in the inner ADAF. The synchrotron emission dominates as a soft photon source due to the large inner disk radius, even with $\beta = 0.97$. In fact, less than 1% of the thin disk photons penetrate the ADAF within $30 R_{\text{Schw}}$, the region where most of the cooling occurs. The small angular size of the disk, as seen by the inner ADAF, also accounts for the weakness of the reflection features in the model spectrum. The EW of the Fe K_α line calculated assuming a neutral cold outer disk is ~ 14 eV, consistent with the $2\text{-}\sigma$ upper limit of 22 eV from the Chandra data.

4. DISCUSSION

The steep slope of the observed spectrum in the EUV band and the smooth power-law emission at higher energies strongly suggest that near 0.1 keV we are seeing the Wien tail of the blackbody emission from the inner disk

² Not shown in Fig. 1, but see HEA and PI

³ When $\beta \rightarrow 1$, the ADAF adiabatic index $\gamma \rightarrow 5/3$, which corresponds to a non-rotating accretion flow with no dissipation (Narayan & Yi 1994; Esin 1997).

edge. PI estimated the temperature of this component to be around 20 – 25 eV. If we assume that the accretion proceeds through a thin disk extending to $3R_{\text{Schw}}$, this inner edge temperature implies a disk accretion rate of $\dot{M} \sim 2 \times 10^{-7} (M/10M_{\odot}) \dot{M}_{\text{Edd}}$. Even at 10% efficiency the bolometric luminosity from an accretion disk with such low \dot{M} is of order $3 \times 10^{32} (M/10M_{\odot})^2 \text{ erg s}^{-1}$, nearly four orders of magnitude lower than the inferred luminosity of XTE J1118+480, $L \gtrsim 7 \times 10^{35} (d/1.1 \text{ kpc})^2 \text{ erg s}^{-1}$. This result is practically unchanged even if the bulk of accretion occurs in the corona above the disk, since as long as the disk is optically thick it will be heated by irradiation (e.g. Dove, Wilms & Begelman 1997a). For example, the magnetic flare model proposed by Merloni, Di Matteo & Fabian (2000) predicts the peak of the disk emission near 0.2 keV, in clear disagreement with both the EUVE and Chandra data. At higher accretion rates, the emission from the inner disk could be hidden by an optically thick corona or occulted by an outer rim of the disk itself. However, the first explanation is ruled out if we assume that the same corona produces power-law emission via inverse Compton scattering, since the cutoff temperature $\gtrsim 250 \text{ keV}$ and photon index 1.8 imply an optical depth in the corona of $\lesssim 0.4$. On the other hand, occultation of the inner part by the disk rim is possible only if the system is nearly edge-on with $90^\circ - i = 5.7^\circ H_{\text{out}}/0.1R_{\text{out}}$. Such a fine-tuned orientation seems unlikely. Moreover, the lack of observed X-ray eclipses due to the companion places an upper limit of 80° on the binary inclination. Thus, occultation by the disk rim can play a role only if the outer disk is very thick⁴, with $H_{\text{out}}/R_{\text{out}} \gtrsim 0.2$. Overall, we feel that a thin disk truncated near $\sim 50 - 70R_{\text{Schw}}$ provides a much more plausible explanation of the observed data.

The interstellar absorption column adopted in this paper, $N_H = 1.15 \times 10^{20} \text{ cm}^{-2}$, is 10% smaller than the preferred value of $1.3 \times 10^{20} \text{ cm}^{-2}$ quoted in PI. The smaller N_H gives a better fit to our theoretical spectrum in the EUV energy band, since the temperature profile of the inner disk is shallower in our model than in the multicolor disk blackbody model used by PI. We also cannot exclude a possibility that the absorption column is even smaller, e.g. $N_H = 0.75 \times 10^{20} \text{ cm}^{-2}$ (as suggested by HEA). In this case, the EUVE spectrum will form a continuation of the power-law component, forcing the transition radius out to $R_{\text{tr}} \gtrsim 160R_{\text{Schw}}$. Thus, lower N_H would only strengthen our overall conclusions.

Di Matteo & Psaltis (1999) have suggested that low-frequency QPO's seen in many black hole systems give an upper limit on the inner radius of a thin accretion disk. A QPO at a frequency 0.07 – 0.15 Hz was seen in optical, UV and X-ray monitoring of XTE J1118+480 (Patterson 2000; Revnivtsev, Sunyaev & Borozdin 2000; Haswell et al. 2000; Yamaoka, Ueda & Dotani 2000; Wood et al. 2000). The formalism of Di Matteo & Psaltis would then predict a transition radius at $\leq 13 - 15 (6M_{\odot}/M)^{2/3} R_{\text{Schw}}$, which is clearly inconsistent with our result in §3, i.e. $R_{\text{tr}} \gtrsim 55R_{\text{Schw}}$, for any allowed value of the black hole mass in XTE J1118+480. It is also unlikely that this discrepancy is due to source variability, since the QPO was observed both before and after the observations discussed

here, and the source emission was quite stable in both the optical and X-ray bands for several weeks around this time (PI).

A somewhat peculiar feature in the X-ray spectrum of XTE J1118+480 is the apparent absence of a turnover at high energies in the summed HEXTE data taken between April 13 and May 15 (see Fig. 1). By comparison, the e -folding energy observed during the 1992 outburst of GRO J0422+32 (a black hole X-ray nova with a similar, persistently hard X-ray spectrum) spanned the range 107 – 130 keV (Esin et al. 1998). The difference in spectra therefore suggests a weaker magnetic field (i.e. larger β) in XTE J1118+480 than previously used to model GRO J0422+32. This is somewhat disturbing, since β is determined by the basic physics of an accretion flow and is not expected to vary significantly from system to system (at least at similar mass accretion rates). Thus, a confirmation of the HEXTE observations is very important. Preliminary data analysis of Beppo-SAX observations of XTE J1118+480 on 2000 April 14 suggests that a high energy cutoff is indeed present below 300 keV (Frontera et al. 2000). If the exact value of the e -folding energy is determined, it will be crucial for constraining the electron temperature and thus, the value of β . On the other hand, if it is convincingly shown that the high energy emission continues above 300 keV without a break, our model (and in fact any thermal emission model) can be effectively ruled out.

The combination of known mass function and simultaneous optical and X-ray observations allowed us to constrain the black hole mass, binary inclination and distance to XTE J1118+480 in the context of our model. For $\beta = 0.5$ we find $d = 2.9 \text{ kpc}$, considerably larger than the estimate of McClintock et al. (2001b) and Wagner et al. (2001); for $\beta = 0.97$ our value, $d = 1.1 \text{ kpc}$, is in better agreement with observations in quiescence and with the distance estimate based on optical spectroscopy in outburst (Dubus et al. 2001). If i , M , and d are better constrained by future observations, their values can be used to constrain β and α in the ADAF model.

Our best-fitting model spectrum with $\beta = 0.97$ corresponds to optical magnitudes $V = 13.1$ and $R = 13.0$ (estimated using standard photometric system conversion from Allen 1973; Wamsteker 1981), respectively ~ 0.2 and ~ 0.4 magnitudes dimmer than what is observed. The rest of the optical emission probably represents a contribution from some non-thermal source (see discussion in §3). Our magnitude estimates are of course upper limits, since we normalized our model in such a way so as to reproduce all of the observed UV flux. It is possible that the non-thermal emission component makes a significant contribution to the HST spectrum even at highest frequencies. In this case the disk emission is dimmer than we estimated here and the best fit black hole mass is somewhat smaller. For example, if the thin disk contributes only 60% of the flux at $2 \times 10^{15} \text{ Hz}$, our $\beta = 0.97$ model requires $M \simeq 7.3M_{\odot}$, $i \simeq 77^\circ$, and $d \simeq 1.0 \text{ kpc}$.

It is tempting to ascribe the spectral break below 2 keV to absorption by an outflowing gas, which is also responsible for the radio and IR excess emission. For

⁴ Note that the lack of eclipses indicate that it is not sufficient to have a warped outer disk; instead H_{out} must reflect a true thickness of the disk.

a spherically-expanding accretion disk wind, the H column density estimated in §3 implies a density $n(R_w) \sim 3 \times 10^{10} (R_{\text{out}}/R_w) \text{ cm}^{-3}$. This is consistent with a few percent of the mass transferred from the companion being launched as a wind from radius R_w at a fraction of a Keplerian velocity. However, the bulk of metal atoms in such a wind will be fully photoionized by the UV/X-ray photons. To avoid this problem, the absorbing material has to be located further away from the system. Since the total mass requirement increases as $\propto N_H R^2$, in this case the observed column density may be due to the accumulation of material ejected during many past outbursts. From a simple photo-ionization balance calculation, we estimate that CIV will be the main ionization state of C outside $\sim 2 \times 10^{15} \text{ cm}$. For a spherical outflow, this implies a lower limit of $10^{-3} (T/10^5 \text{ K}) M_\odot$ on the total mass of the absorbing material at temperature T . For a time-average mass transfer rate of $\dot{M}_T \sim 10^{16} \text{ g s}^{-1}$, expected in XTE J1118+480 from binary evolution theory (King et al. 1996), this amount of material can easily be lost in a wind over $\sim 10^7 \text{ yr}$ (a much shorter time than the typical age of a low mass X-ray binary).

The estimates above depend strongly on the assumed metal abundances. Based on the optical/UV spectroscopy of XTE J1118+480 in outburst, Haswell et al. (2001) and Dubus et al. (2001) suggest that the accreting material has low abundances of C and O as compared to N; they attribute this to CNO processing. This interpretation may help to explain the lack of a prominent O edge in the X-ray spectrum of XTE J1118+480 but it is not consistent with our interpretation of the strong $\sim 300 \text{ eV}$ feature as a C K-edge.

Finally, it is also possible that the absorbing material is not associated with the system. In the future, as our understanding of the detector response continues to improve, we plan to do a more detailed analysis of the Chandra spectrum, placing limits on the position and strength of individual absorption edges. Together with a detailed model of the absorbing material, which would include a

realistic calculation of the ionization balance, this work should shed some light on the physical properties and the origin of the warm absorber.

5. SUMMARY

The ADAF model proposed by Esin et al. (1997) to explain the low state spectra of accreting black holes can explain the observed spectrum of the new transient source, XTE J1118+480, in outburst. In the case of Nova Muscae, due to the lack of UV and soft X-ray data, Esin et al. (1997) could not constrain the position of the transition region between an outer thin disk and an inner hot ADAF, beyond requiring that it must lie outside $\sim 30 R_{\text{Schw}}$ from the black hole (Esin et al. 1998). The unprecedented multi-wavelength observations of XTE J1118+480 (HEA; PI) allow a direct determination of the position of the inner edge of the thin disk. We show that the simultaneous optical, UV and X-ray data can be explained by an ADAF+disk model with a transition radius at $55 R_{\text{Schw}}$, accreting onto a $\sim 9 M_\odot$ black hole at a rate 2% of Eddington, and a source distance of $d \sim 1.1 \text{ kpc}$. We find that we need a fairly high value of β in our model, i.e. weak magnetic fields, to reproduce the unusually high cutoff energy found in the HEXTE observations of XTE J1118+480. Finally, we attribute the hardening of the soft X-ray spectrum below 2 keV to the presence of a warm absorbing medium between us and the system.

AAE thanks Jonathan Kawamura and Roger Blandford for helpful suggestions and discussions, and Kristen Menou for help with high- β dynamical models. AAE was supported by NASA through Chandra Postdoctoral Fellowship grant #PF8-10002 awarded by the Chandra X-Ray Center, which is operated by the SAO for NASA under contract NAS8-39073. JEM, MRG and JJD acknowledge NASA support from grant DD0-1003X and contract NAS8-39073. CAH & RIH are supported by grant F/00-180/A from the Leverhulme Trust.

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